REDACTED VERSION

APPENDIX NOT INCLUDED

Soil Feasibility Study Report
Wilcox Oil Company Superfund Site
Bristow, Creek County, Oklahoma
EPA Identification No. OK0001010917

Remedial Investigation/Feasibility Study
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TABLE OF CONTENTS

Page

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS AND ABBREVIATIONS

95 UCLM	95 Upper confidence limit of the mean
μg/L	Microgram(s) per liter
ARAR	Applicable or relevant and appropriate requirement
bgs	Below ground surface
BaP	Benzo(a)pyrene
BRAPF	Baseline Risk Assessment Problem Formulation
CalEPA	California Environmental Protection Agency
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cm/s	Centimeter per second
COC	Chemical of concern
COPEC	Constituent of potential ecological concern
COPC	Chemical of potential concern
CSM	Conceptual site model
cy	Cubic yard(s)
EA	EA Engineering, Science, and Technology, Inc., PBC
EPA	U.S. Environmental Protection Agency
EPC	Exposure point concentration
ERA	Ecological Risk Assessment
FS	Feasibility Study
ft	Foot (feet)
GRA	General Response Action
HDPE	High density polyethylene
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard quotient
IC	Institutional control
IEUBK	Integrated Exposure Uptake Biokinetic
ISB	In situ enhanced bioremediation
ISCO	In situ chemical oxidation
ISS	In situ stabilization and solidification
LNAPL	Light non-aqueous phase liquid
LTU	Land treatment units
LUC	Land use control

MCL	Maximum contaminant level
mg/kg	Milligram(s) per kilogram
mil	Milli-inch

LIST OF ACRONYMS AND ABBREVIATIONS (CONTINUED)

NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NFA	No further action
NPL	National Priorities List
OAC	Oklahoma Administrative Code
ODEQ	Oklahoma Department of Environmental Quality
OSWER	Office of Solid Waste and Emergency Response
PAH	Polycyclic aromatic hydrocarbon
PEL	Probable effects level
PRG	Preliminary remediation goal
RA	Remedial Alternatives
RAC	Remedial Action Contract
RACER	Remedial Action Cost Engineering and Requirements
RAO	Remedial action objective
RCRA	Resource Conservation and Recovery Act
RI	Remedial investigation
ROD	Record of Decision
RSL	Regional screening level
sf	Square foot
Site	Wilcox Oil Superfund Site
SLERA	Screening Level Ecological Risk Assessment
SVOC	Semivolatile organic compound
TBC	To be considered
TMV	Toxicity, mobility, or volume
TRV	Toxicity reference value
VOC	Volatile organic compound
XRF	X-ray fluorescence

1. INTRODUCTION

EA Engineering, Science, and Technology, Inc., PBC (EA) has prepared this Feasibility Study (FS) Report for the U.S. Environmental Protection Agency (EPA) for the Wilcox Oil Company Superfund Site (site) in Bristow, Creek County, Oklahoma (Figure 1-1) under Remedial Action Contract (RAC) Number EP-W-06-004 and Task Order 0128-RICO-06GG. This report addresses soil contamination at the site. The groundwater extent of contamination remains under investigation and will be addressed in a separate report.

This revised FS Report, incorporates the comments from EPA and Oklahoma Department of Environmental Quality (ODEQ) on the FS Report, Revision 00 which was submitted on 8 January 2021. The responses to comments on the FS Report, Revision 00 are provided in Appendix A.

EA prepared this report based on the Remedial Investigation (RI) Report, Revision 02 (EA 2020a), Human Health Risk Assessment (HHRA), Revision 03 (EA 2020b), and Screening Level Ecological Risk Assessment (SLERA), Revision 01 (EA 2020c), and in accordance with regulations and guidance documents that include, but are not limited to, the following:

- National Oil and Hazardous Substance Pollution Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) Part 300

- *Guidance for Conducting Remedial Investigation and Feasibility Studies under Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA), Office of Solid Waste and Emergency Response [OSWER] Directive 9355.3-01 (EPA 1988)

This FS was drafted following the framework provided in the EPA Guidance for Conducting RIs and FS under CERCLA (EPA 1988).

1.1 PURPOSE AND SCOPE

The purpose of this report is to support identification and evaluation of potential remedies that address soil contamination at the site by:

- proposing the preliminary remedial action objectives (RAOs);

- defining specific preliminary remediation goals (PRGs); and,

- developing and analyzing a range of remedial alternatives (RAs).

1.2 REPORT ORGANIZATION

This FS is divided into the following chapters:

- ***Chapter 1, Introduction***—Presents the purpose of this FS Report and its organization.
- ***Chapter 2, Site Description and Background***—Provides a summary of the site history, results of RI, HHRAs and ecological risk assessments (ERAs), site conceptual site model, and potential groundwater remedial technologies.
- ***Chapter 3, Groundwater Data Gap and Potential Technologies***—Discusses existing data gap for groundwater and technologies that may be considered for future groundwater remediation.
- ***Chapter 4, Remedial Action Objectives***—Defines RAOs, proposes PRGs, and identifies the applicable or relevant and appropriate requirements (ARARs) for the site.
- ***Chapter 5, Development and Screening of Technologies***—Identifies and screens various potential remedial technologies and options that may be used to address contaminant of concern (COC)-impacted soil.
- ***Chapter 6, Development of Remedial Alternatives***—Presents the remedial alternatives and the components of each alternative.
- ***Chapter 7, Evaluation of Remedial Alternatives***—Presents the detailed analysis and comparative analysis of the alternatives.
- ***Chapter 8, References***—Provides the list of references used in this report.

2. SITE DESCRIPTION AND BACKGROUND

2.1 SITE DESCRIPTION

The Wilcox Oil Company site is an abandoned and demolished oil refinery and associated tank farm located north of Bristow, Creek County, Oklahoma (Figure 1-1). It is situated by Route 66 to the west; a residential area and Turner Turnpike to the north and northwest; Sand Creek to the west and southwest; and residential, agricultural, and wooded areas to the east and south. The approximate geographic coordinates for the site are 35°50’31” North latitude and 96°23’02” West longitude (EA 2020a). The site spans approximately 140 to 150 acres and has been divided into five (5) major former operational areas (Figure 2-1):

- The Wilcox Process Area
- The Lorraine Process Area
- The East Tank Farm
- The North Tank Farm, and
- The Loading Dock Area.

Previous activities associated with the facility operations caused site contamination. Some refinery waste is still present at the site, and the site is fenced and secured to deter trespassing and potential contact with the waste.

The Wilcox Process Area is approximately 26 acres in size and is fenced. Most of the equipment and storage tanks used in the past were auctioned and/or salvaged by private land owners; any remaining structures are in ruins. Four aboveground storage tanks, a number of discarded drums and pieces of scrap iron and piping remain at the site. A former lead additive area is barren and located at the southwest portion of the Wilcox Process Area. There are multiple areas of stressed vegetation, barren soil, and visible black tarry waste of a hydrocarbon nature. Buildings in the northern and eastern parts of the former refinery were used as residences and are therefore considered as such, although they are currently vacant. An intermittent creek (West Tributary) flows southward across the eastern portion of the refinery process area through a small pond in the southeast corner of the Wilcox Process Area into Sand Creek. Hydrocarbon waste has also been observed in several drainage channels that empty into Sand Creek.

The Lorraine Process Area is approximately 8 acres, fenced, and to the west of the Wilcox Process Area across the railroad tracks. No refinery structures remain in the area. The First Assembly of God Church (currently vacant), a playground, and a vacant residence (parsonage) are located in this area. Sand Creek borders the western boundary of the area. A drainage feature is located near the northwestern corner of the former process area that drains south into Sand Creek. Similar to the Wilcox Process Area, there are multiple areas of stressed vegetation, barren soil, and visible, black tarry waste present in the area.

The East Tank Farm is located to the east of the Wilcox Process Area and is approximately 80 acres. The area includes pits, ponds, and a number of circular berms that surrounded former tank locations. All of the former crude oil storage tanks have been removed; however, remnants of the former tank locations remain visible. It is not known if underground piping associated with the tanks remains in place or was removed. Many of the berms surrounding the pits, ponds, and former tanks have been breached or leveled. The three residential properties, which are occupied, are located on or directly next to former tank locations in the East Tank Farm. There are multiple areas of stressed vegetation, barren soil, and visible black tarry waste. The East Tributary is located along the eastern boundary of the East Tank Farm and perennially flows south through a series of ponds to Sand Creek.

Magellan Midstream Partners, LP operates a pumping station in the north-western portion of the East Tank Farm Area, as well as an active pipeline that transects the East Tank Farm, Loading Dock, and North Tank Farm Areas from the southeast to the northwest. Magellan Midstream Partners, LP pumps several different petroleum products through the active pipeline, including kerosene, gasoline, jet fuel, and diesel.

The North Tank Farm is located north of Refinery Road, also referred to as E0810, and west of the railroad tracks and is approximately 20 acres. All of the tanks and other structures that were used to support Lorraine Refinery have been removed. An occupied residence is located in the center of the North Tank Farm. There are areas of stressed vegetation, and visible black tarry waste is present.

The Loading Dock Area is approximately 7 acres and is located north of the Wilcox Process Area and east of the North Tank Farm and railroad tracks. The Loading Dock Area was used for loading and unloading product by rail. There are multiple areas of stressed vegetation, barren soil, and visible black tarry waste of a hydrocarbon nature, similar to the rest of site.

2.2 SITE HISTORY

The property was used for oil refinery operations from 1915 until about November 1963. A modern, upgraded oil refinery plant was constructed in 1929 and consisted of a skimming plant, cracking unit, and re-distillation battery with a vapor recovery system and treatment equipment. The Wilcox Oil Company expanded when it acquired the Lorraine Refinery in 1937. Wilcox Oil Company sold the property to a private individual in 1963. Most of the equipment and storage tanks were auctioned or salvaged for scrap metal by the new property owners. Wilcox Oil Company currently no longer operates in Oklahoma. Based on information from the Oklahoma Secretary of States' office, the company merged with Tenneco Oil Company in 1967. On 24 May 2013, EPA proposed the site to the National Priorities List (NPL). On 12 December 2013, the site officially became a Federal Superfund site (EPA Identification No. OK0001010917), when it was added to the NPL.

2.2.1 Previous Investigation and Removal Activities

The EPA and ODEQ have conducted multiple investigations at the site since 1994. The details of the investigations can be found in the individual documents listed in the RI Report (EA 2020a).

In September and October 2017, EPA conducted a removal action and removed oily, tarry sludge and contaminated soils from a residential property at the site. Approximately 1,329 tons of impacted soils and sludge were removed and disposed offsite (Weston 2017). The area was backfilled with clean soil, graded, and reseeded.

2.2.2 Source Control Record of Decision Summary

A Source Control Record of Decision (ROD) Summary was issued in September 2018. The Source Control ROD is limited in scope and addresses specific refinery tank waste locations and the lead additive area source material through excavation, treatment, and offsite disposal (EPA 2018). This source control action is an early/interim action that does not constitute the final remedy for the site; therefore, any subsequent actions to address the remaining risks and threats posed by the site conditions will be documented in a final site-wide decision document. This FS Report provides support for the site-wide decision document.

2.3 SURFACE FEATURES

The site topography generally slopes to the south and southwest on the western portion of the site toward Sand Creek and southeast on the eastern portion of the site towards the East Tributary. Sandstone outcrops are present throughout. The railroad tracks run through the western portion of the site, and divides the North Tank Farm and Loading Dock Area; and Wilcox Process and Lorraine Process Areas. Several drainage features are present at the site. The West Tributary, an intermittent stream, is located along the eastern side of the Wilcox Process Area; the East Tributary, a perennial stream, and five ponds are located within the East Tank Farm; and several smaller drainage channels transect the southern portion of the Wilcox Process Area east of the railroad. All streams and channels flow southward to Sand Creek (EA 2020a) at the southern and southwestern boundaries of the site. Sand Creek meanders approximately 3.5 miles south and east from the site until it merges with Little Deep Fork Creek.

A wetland survey was conducted in September 2016 and identified 4 wetland areas at the site (EA 2017) (Figure 2-2). Two wetlands are located in the Wilcox Process Area, one in the North Tank Farm and one in the East Tank Farm. Among the 4 wetlands, 3 are connected with Sand Creek, which are Wetland 2 in the Wilcox Process Area associated with West Tributary, Wetland 3 in North Tank Farm with vegetated drainage ditches to Sand Creek, and Wetland 4 in East Tank Farm along the East Tributary. Wetland 1 in the Wilcox Process Area is not directly connected with any tributaries and appears to obtain water from surficial runoff (EA 2017).

There are seven residential buildings/houses at the site, one in the North Tank Farm, one in the Lorraine Process Area, two in the Wilcox Process Area, and three in the East Tank Farm. The houses in the Lorraine Process Area and Wilcox Process Area are currently unoccupied while the rest of the houses in the other areas are occupied. A church and a playground are located in the Lorraine Process Area.

Staining of the soil, black tarry waste, stressed vegetation, and barren areas are present throughout the site. Storage tanks, refinery-related debris, and piping still remain in the Wilcox

Process Area, while evidence remains of former tank berms that were cut and leveled in the East Tank Farm (EA 2020a).

2.4 FUTURE LAND AND GROUNDWATER USE

Residential use is expected to continue for all residential properties in the East Tank Farm, Lorraine Process Area, and Wilcox Process Area. A large portion of the East Tank Farm, currently used for grazing, may be used as a residential property in the future based on discussions with the current landowner. The residential area in the Wilcox Process Area includes the house, storage tanks, and driveway.

The remaining portion of the Wilcox Process Area consists of the remaining refinery structures and features, which is currently unused. It is likely that the anticipated reuse for this property would be industrial; however, residential considerations for this portion remains.

Residential properties associated with the North Tank Farm, the Lorraine Process Area, and one property along Refinery Road in the Wilcox Process Area are currently on public water supply. The public water system is supplied by 4 city water wells approximately 400 feet (ft) deep in the Vamoose-Ada aquifer. Residences located on or near the East Tank Farm, and the southernmost property in the Wilcox Process Area obtain water from individual groundwater wells set in the Barnsdall Formation, which is much shallower than the Vamoose-Ada aquifer (EA 2020a).

2.5 GEOLOGY AND HYDROGEOLOGY

The site is situated on the Pennsylvanian-aged Barnsdall Formation, which is composed of fine-grained sandstone overlain by shale. Thickness ranges from 80 to 200 ft (ODEQ 2008) but is approximately 200 ft thick at the site. Sandstone outcrops of the Barnsdall Formation are common throughout the site. Southeast of the former refinery, the underlying Pennsylvanian-aged Wann Formation and underlying Iola Limestone are exposed. The Wann Formation varies in thickness from 40 to 180 ft and is comprised of shale and fine- to medium-grained sandstone. The Iola Limestone ranges in thickness from 15 to 20 ft and consists of a calcareous fine-grained sandstone and limestone with some shale.

Approximately 0.25 miles to the southeast of the former refinery, Quaternary-aged alluvial deposits associated with Sand Creek occur. These deposits consist of sand, silt, clay, and lenticular beds of gravel that overlie the older geologic units where these deposits exist. Thickness in these deposits ranges from 5 to 50 ft (25 ft average). Given that Sand Creek borders the site to the south, localized alluvium may be present (ODEQ 2009).

The Barnsdall Formation is a bedrock aquifer and is not considered a principal groundwater resource by the Oklahoma State Department of Health (ODEQ 1994). It consists of massive-to-thin beds of coarse-to-fine grain sandstone, irregularly interbedded with sandy to silty shale. Under the Barnsdall Formation lies the Vamoose-Ada aquifer in close proximity to the west of the site. The Vamoose-Ada aquifer is an important central Oklahoma regional drinking water aquifer (E&E 1999), which is the source for the public water supply in the area.

The shallowest regional water-bearing formation in the upper part of the Barnsdall Formation is unconfined and is overlain by the unconfined shallow perched groundwater zone. The Barnsdall Formation potentially receives groundwater recharge from precipitation and infiltration from the perched groundwater zones. The shallowest regional water-bearing formation (associated with the Barnsdall Formation) is reportedly less than 25 ft bgs (ODEQ 1994). Depths to seasonal perched groundwater zones are less than 10 ft and depth to groundwater ranged from 4.84 to 15.97 ft below ground surface (bgs) in the groundwater monitoring wells installed within the Lorraine and Wilcox Process Areas. The primary groundwater flow path for the perched groundwater zone is to the south towards Sand Creek. Figure 2-3 presents a potentiometric surface map based on 2018 data. The local gradient averages approximately 0.021 foot per foot across this portion of the site at an estimated velocity of ???/year.

2.6 REMEDIAL INVESTIGATION RESULT SUMMARY

The RI was conducted during a series of eight field events that occurred from August 2016 through December 2018. In 2016, a geophysical survey, a Rapid Optical Scanning Tool laser-induced fluorescence survey, and a field-portable X-ray fluorescence (XRF) survey across portions of the Wilcox Process Area, the Lorraine Process Area, and the East Tank Farm was performed as well as a passive soil gas survey and vapor intrusion sampling. A total of 473 surface soil samples, 355 subsurface soil samples, 44 sediment samples, 56 surface water samples, 35 groundwater samples, and multiple waste characterization samples (16 waste and multiple test pits locations where waste was visibly present) were collected during the sampling events (EA 2020a). In August 2020, a data gap investigation primarily associated with groundwater sampling was completed.

Samples collected during the RI were analyzed for volatile organic compounds (VOCs) including 1,2-dibromoethane (EDB), polycyclic aromatic hydrocarbons (PAHs), semivolatile organic compounds (SVOCs), target analyte list (TAL) metals (including mercury), and cyanide. A portion of these samples were also analyzed for hexavalent chromium, polychlorinated biphenyls, dioxins/furans, and soil parameters. Additionally, sediment analyses included acid volatile sulfide and simultaneously extracted metals, moisture, percent total solids and pH, while additional surface water parameters included hardness, pH, total dissolved solids, total suspended sediment, and alkalinity.

The vapor intrusion investigation included a passive soil gas survey targeting a select list of volatile organic compounds, including benzene. Based on these results, additional sampling was conducted at existing structures to further assess the potential for vapor intrusion and included ambient air samples, indoor air sampling, sub-slab air sampling and a crawl space sample. Samples were analyzed for VOC using method TO-15. Indoor air samples were collected from existing buildings within the Lorraine Process Area and Wilcox Process Area.

The August Data Gap investigation focused on groundwater sampling conducted at existing wells and at new, temporary well locations to further delineate possible contaminant plumes in the Wilcox Process Area and the Lorraine Process Area. Aquifer tests were performed at existing monitoring wells to determine site-specific hydraulic parameters necessary for developing groundwater models to evaluate potential remedial options for aquifer restoration. Groundwater levels in existing monitoring wells were gauged and a survey of Sand Creek was conducted to establish static water level and investigate possible communication between the groundwater and creek. Supplemental surface waste samples were collected to provide additional data on potential waste sources. Appendix B provides details of the data gap investigation.

The RI results indicated that the site soil, sediment, surface water, and groundwater have been impacted by the refinery operations and contain concentrations of contaminants that required further review and evaluation under a human health risk assessment and an ecological risk assessment.

2.7 SUMMARY OF HUMAN HEALTH RISK ASSESSMENT

The following sections summarize the Human Health Risk Assessment (HHRA).

2.7.1 Introduction

The role of the HHRA is to quantify the risks associated with potential exposure to hazardous substances at a site in the absence of any remedial action or control, including institutional controls (ICs) (e.g. property use restrictions). A HHRA was performed to estimate the probability and magnitude of potential adverse human health effects from exposure to contaminants associated with the site assuming no remedial action was taken. The HHRA aids in risk management decisions and provides the basis for taking action. The HHRA identifies the exposure areas, exposure pathways, and contaminants that may be considered for remedial action.

The HHRA followed EPA methodology and included the following information: the methodology for data grouping and identification of COPCs, the exposure assessment, the toxicity assessment, the site-specific risk assessment results, and the uncertainty analysis.

2.7.2 Data Grouping and COPC Identification

Sampling for the RI occurred over multiple field events from August 2016 to December 2018. As part of the RI field investigation, soil, groundwater, sediment, surface water, indoor air, and sub-slab soil gas samples were collected. The EPA risk-based screening levels (EPA 2019) were the primary screening levels used for risk-based screening purposes in the HHRA, and COPCs were identified by comparing the maximum detected concentration to the appropriate screening level. COPCs are chemicals that are carried through the quantitative exposure and risk estimate portions of the HHRA.

Based upon the process areas and site use, the site was divided into five major former operational areas: the Wilcox and Lorraine Process Areas, the East and North Tank Farms, and the Loading

Dock Area. The HHRA determined COPCs and evaluated potential risk concerns based upon these five operational areas.

2.7.3 Exposure Assessment

In the exposure assessment, the receptors of concern and potential exposure pathways were identified.

Current On-Site Trespasser - The risk to current Site trespassers was evaluated based on exposure to Site surface soil (0 to 6 inches bgs) and sediment/surface water including the drainages, ponds, and Sand Creek.

- Incidental ingestion of surface soil
- Dermal contact with surface soil
- Inhalation of particulates from windblown soil released to outdoor air
- Incidental ingestion of surface water
- Dermal contact with sediment and surface water

Future On-Site Child and Adult Residents - The risk to future Site child and adult residents was evaluated based on exposure to Site surface (0 to 2 feet bgs) and subsurface soil (2-10 feet bgs), sediment/surface water including the drainages, ponds, and Sand Creek, groundwater, and home-grown produce/beef.

- Incidental ingestion of soil
- Dermal contact with soil
- Inhalation of chemicals adsorbed to windblown soil released to outdoor air
- Incidental ingestion of surface water
- Dermal contact with sediment and surface water
- Ingestion of groundwater
- Dermal contact with groundwater
- Inhalation of chemicals volatilized from groundwater during domestic use
- Ingestion of home-grown produce
- Ingestion of beef

Future On-Site Commercial/Industrial Worker - The risk to future Site industrial workers was evaluated based on exposure to Site surface (0 to 2 feet bgs) and subsurface soil (2-10 feet bgs), and groundwater.

- Incidental ingestion of surface soil
- Dermal contact with surface soil
- Inhalation of particulate from windblown soils released to outdoor air
- Ingestion of groundwater

• Dermal contact with groundwater
• Inhalation of chemicals volatilized from groundwater during use as a water supply

Future On-Site Construction Workers - The risk to future Site Construction workers was evaluated based on exposure to Site surface (0 to 2 feet bgs) and subsurface soil (2-10 feet bgs),and groundwater.

• Incidental ingestion of soil
• Dermal contact with soil
• Inhalation of chemicals absorbed to windblown soil in outdoor air (i.e. fugitive dust)
• Dermal contact with groundwater and subsequent incidental ingestion
• Inhalation of volatiles while working in a trench

2.7.4 Risk Characterization

The final step in the HHRA is the characterization of the potential risks associated with exposure to chemicals detected at a site. The HHRA evaluated each of the five operational areas for potential cancer risks and noncancer hazards from soil, sediment, surface water, groundwater, and ambient air.

Results of the human health risk assessment are listed below and further discussion related to preliminary remediation goals is provided in Section 4 and Appendix C.

Indoor air samples from existing buildings within the Lorraine Process Area and Wilcox Process Area did reveal the presence of COPCs. However, sub-slab soil gas samples did not reveal any COPCs below these buildings. As a result, the indoor air COPCs are likely a result of indoor source areas and not vapor intrusion from groundwater. Therefore, vapor intrusion from groundwater into existing buildings at the site is not considered complete, and indoor air COPCs were not assessed further in the HHRA.

For all receptors and all operational areas, the

- potential exposures to surface water and sediment at the site do not exceed the EPA acceptable cancer risk range, and noncarcinogenic hazards are below the level of concern. Therefore, these media are not expected to pose human health concerns and no contaminants of potential concern are identified for surface water or sediment.
- potential exposures to soil at the site do not exceed the EPA acceptable cancer risk range. Soil is not expected to pose excess cancer risk concerns; therefore, no contaminants of potential concern are identified for soil. (Further assessment of benzo(a)pyrene is discussed in the following section.)
- risk assessment determined that potential non-cancer hazards associated with exposures to soil through the ingestion of home produce and beef may be present for all areas, and is primarily associated with the metals cobalt, iron, and copper. These metals are sporadically detected across the soil medium, are collocated within proposed remediation areas, and are less than background (cobalt and copper). There is a high degree of

uncertainty in the models because these pathways model potential health impacts from surface soil concentrations rather than actual produce and/or beef concentrations. Due to uncertainties associated with uptake from soil and the conservative assumptions in the model, the results are likely an overestimation of potential risk. None of these metals were identified as significant contributors to risk or as significant contributors based on target organs. As a result, these metals are not identified as COPCs.

For all receptors and the East Tank Farm, North Tank Farm and the Loading Dock operational areas, the

- potential exposures to lead in soil do not result in a greater than 5% chance of exceeding a target blood lead level of 5, 8 or 10 micrograms per deciliter (µg/dl); therefore, lead in soil is not identified as a contaminant of potential concern for these areas. (Further assessment of lead in the East Tank Farm is discussed in Section 4.)

For the Lorraine Process Area, the

- potential exposures to lead in soil by the future resident child may result in a greater than 5% chance of exceeding a target blood lead level of 5, 8 or 10 micrograms per deciliter (µg/dl); therefore, lead in soil is identified as a contaminant of potential concern for this area.
- potential exposures to lead in soil by the future commercial/industrial worker may result in a greater than 5% chance of exceeding a target blood lead level of 5 micrograms per deciliter (µg/dl); therefore, lead in soil is identified as a contaminant of potential concern for this area.
- potential exposures to lead in soil do not result in a greater than 5% chance of exceeding a target blood lead level of 5, 8 or 10 micrograms per deciliter (µg/dl) for the construction worker; therefore, lead in soil is not identified as a contaminant of potential concern for this receptor.

For the Wilcox Process area, the

- potential exposures to lead in soil by the future resident child may result in a greater than 5% chance of exceeding a target blood lead level of 5, 8 or 10 micrograms per deciliter (µg/dl); therefore, lead in soil is identified as a contaminant of potential concern for this area.
- potential exposures to lead in soil by the future commercial/industrial worker may result in a greater than 5% chance of exceeding a target blood lead level of 5 micrograms per deciliter (µg/dl); therefore, lead in soil is identified as a contaminant of potential concern for this area.
- potential exposures to lead in soil do not result in a greater than 5% chance of exceeding a target blood lead level of 5, 8 or 10 micrograms per deciliter (µg/dl) for the construction worker; therefore, lead in soil is not identified as a contaminant of potential concern for this receptor.

Groundwater potential risks were assessed based upon monitoring well results within the perched aquifer. The human health risk assessment determined that potential exposures to groundwater exceed the EPA acceptable cancer risk range and the noncarcinogenic hazard level of concern for the resident, industrial worker, and construction worker. Due to the need for additional ground water data, further identification of COPCs and evaluation of potential alternatives will be conducted at a future date. Refer to Section 3 and Appendix B for further discussion.

2.7.5 Additional Evaluation of Potential Risk Concerns

The HHRA evaluated potential human health concerns based on the entire exposure area of each of the five operational areas. However, these areas are larger than areas that are typically evaluated for residential yards. To further evaluate the surface soil medium of concern and evaluate potential concerns for smaller exposure areas (i.e., potential residential yards), sample results were reviewed to determine if areas of high concentrations are present in soil within the five operational areas. High detections of benzo(a)pyrene are present on the Lorraine Process Area, within the northwest area, along E0810 Road, and just north of the church's parking lot. This grassy area is approximately 1 acre, which is equivalent to an average residential yard for the area. The high concentrations were detected in this area and all samples collected were combined to determine a benzo(a)pyrene exposure point concentration of 24.1 mg/kg based on the 95% upper confidence limit of the mean (95UCLM). The resulting cumulative, lifetime excess carcinogenic risk was 2 x 10-4, which exceeds the EPA acceptable risk range. Noncarcinogenic hazards were 1 and 0.2 for the resident child and resident adult, respectively. As a result, benzo(a)pyrene is identified as a contaminant of potential concern for this area.

For the Lorraine Process Area,
- potential exposure to benzo(a)pyrene in soil exceeds the EPA acceptable cancer risk range, and may pose a potential risk to the future child resident. Benzo(a)pyrene in soil is identified as a contaminant of potential concern in the Lorraine Process Area.

2.8 SUMMARY OF ECOLOGICAL RISK ASSESSMENT

EA conducted a SLERA in January 2020 following Steps 1, 2 and 3 of EPA's Ecological Risk Assessment Guidance (EPA 1997, 1998). This section provides an overall summary of the ecological risk assessment.

2.8.1 Introduction

The purpose of the SLERA was to characterize and quantify potential environmental impacts from residual chemicals in soil, sediment, and surface water from site activities. The assessment was conducted in accordance with the process outlined in the document, *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (EPA 1997) and other relevant EPA guidance.

The process for ERA outlined in EPA guidance includes eight steps (EPA 1997, 1998). Steps 1 and 2 represent the SLERA. The SLERA uses precautionary assumptions regarding exposure and toxicity to develop a conceptual site model (CSM) and identify constituents of potential ecological concern (COPECs). The CSM defines complete and significant exposure pathways and identifies assessment and measurement endpoints. The screening level evaluation relies on chemical analytical data.

Step 3 of the SLERA process is the Baseline Risk Assessment Problem Formulation (BRAPF). The BRAPF draws from the risk evaluation performed in the SLERA to identify COPECs, exposure pathways, assessment endpoints, and risk questions requiring further consideration. The BRAPF often includes a refinement of the screening level risk calculations through more realistic or more relevant exposure and toxicity data. The goal of the BRAPF is to provide a clear definition of the potential ecological risks for the site. This problem formulation forms the basis for either further assessment or, in cases where sufficient data are available, risk management if necessary. In the case of this site, SLERA and BRAPF refinement of risk calculations were performed.

2.8.2 SLERA Results

Potential receptors evaluated in the SLERA for the site include plants, soil invertebrates, amphibians and reptiles, birds, mammals, benthic invertebrates, and aquatic organisms. Potential ecological receptors and scenarios are shown in the CSM (Figure 2-8).

The SLERA used conservative assumptions, including conservative toxicity reference values (TRVs) and input parameters for food web models (e.g., 100% site use, 100% earthworm ingestion, etc.). The evaluation also assumed maximum exposure scenarios [e.g., maximum ingestion rates and exposure point concentrations (EPCs)]. Modifications were conducted as part of Step 3 of the ERA process that used more realistic EPCs (i.e., 95UCLM of the data) and incorporated lowest effect level TRVs. Despite the modifications, the SLERA identified potential risks (based on hazard quotients [HQs] greater than 1).

2.8.3 SLERA Refinement

SLERA refinement was conducted to evaluate COPECs for lower trophic level receptors (e.g., benthic invertebrates, plants, and soil invertebrates) that had SLERA HQs greater than 1 based on 95UCLMs. Further details are included in Appendix C of this report. The findings of the risk assessment are as following:

- The risk assessment determined that potential risks associated with exposures to lead in site soil (all 5 areas) are present for plants, insectivorous mammals, insectivorous birds, and herbivorous birds. Areas of concern are collocated with human health remediation areas; therefore, remediation based on an ecological lead exposure PRG is not proposed for soil.

- The risk assessment determined that potential risks associated with exposures to vanadium in the site soil (all 5 areas) are present for plants and insectivorous birds. Areas of concern are collocated with human health remediation areas; therefore, remediation based on an ecological vanadium exposure PRG is not proposed for soil.

- Potential risks to aquatic organisms in the ponds (cadmium, lead, benzo(a)pyrene) and streams (manganese) from elevated concentrations of contaminants in the water column are likely to be reduced following removal of contaminated soil in the uplands. No remediation based on potential risks associated with surface water is proposed.

- Concentrations of total PAHs in stream sediment, when compared to the probable effects level (PEL) of 16.8 mg/kg (MacDonald et al 1996) indicates no potential risk to benthic organisms from total PAHs in stream sediments; therefore, no remediation based on potential risks to benthic invertebrates from PAHs is proposed.

- Because of infrequent detections of volatile organic compounds, the volatile nature of the chemicals, the absence of direct toxicological studies, and the unsubstantiated theoretical nature of the soil screening values, it is not expected that VOCs would result in unacceptable risk to populations of soil invertebrates; therefore, no remediation based on potential risks to soil invertebrates from VOCs is proposed.

- It is unlikely that there would be adverse impacts to the plant or soil invertebrate communities at the site from sporadic elevated concentrations of metals (zinc, manganese, copper, and chromium) based on the following, and as a result, no remediation based on potential risks to plants or soil invertebrates is proposed.

    - Low HQs identified in the SLERA, based solely on a screen against Ecological Soil Screening Levels or screening benchmarks from Efroymson et al. (Efroymson et al 1997a,b).
    - Low potential for uptake and toxicity from naturally occurring metals, many of which are essential nutrients.
    - Sporadic elevated concentrations not linked to facility activities.
    - Lack of sufficient ecological habitat from long-term and/or continued future industrial, residential, and agricultural usage of many portions of the site.
    - Removal of select concentrations of metals during excavations for lead and/or benzo(a)pyrene, reduces the overall HQs.

3. GROUNDWATER DATA GAP AND POTENTIAL TECHNOLOGIES

Groundwater was investigated and poses unacceptable risk to human health as indicated in the previous section of this FS Report. A data gap investigation was conducted in August 2020. The following subsection summarizes the data gap investigation results, and detailed results are provided in Appendix B. Although this FS only addresses the soil contamination, this section provides information on potential technologies that may be considered for future groundwater remediation.

3.1 GROUNDWATER DATA GAP

The HHRA identified potential health risks associated with exposure to groundwater in the perched shallow groundwater unit, which could be utilized for domestic use, in the Wilcox Process Area and Lorraine Process Area.

Due to the limited groundwater data available, it was determined that a data gap investigation would be required to collect additional data on site groundwater conditions. Temporary wells were installed, and groundwater samples were collected at old and new monitoring wells, temporary wells, and water wells. Aquifer tests were performed at existing monitoring wells to evaluate site-specific hydraulic parameters. Groundwater levels were gauged, and a survey of Sand Creek was conducted to evaluate potential communication between groundwater and the creek. The data gap investigation results are summarized in the Technical Memorandum on Data Gap Investigation (Appendix B).

3.2 POTENTIAL GROUNDWATER REMEDIAL TECHNOLOGIES

A few potential technologies for the site groundwater can be explored based on the current understanding of the site, i.e., pump-and-treat, *in situ* enhanced bioremediation (ISB); *in situ* chemical oxidation (ISCO), and *in situ* stabilization and solidification (ISS). A full evaluation of alternatives should be conducted once more data are collected.

A light non-aqueous phase liquid (LNAPL) is present within the Wilcox Process Area and is identified as gasoline based on current data. The LNAPL's quantity, mobility and recoverability are currently not known, but if the LNAPL is found mobile and highly recoverable, potentially pump-and-treat or skimming technologies can be used to recover the LNAPL for offsite disposal. Based on the LNAPL observation at MW-04, however, its recovery rate is likely low and pumping may not be effective. Depending on remedial objectives, for mass control and reduction of mobility, ISS may be used to physically/chemically bind LNAPL with stabilizing reagents. However, institutional controls (ICs) should be put in place to protect the stabilized area, and long term monitoring may also be necessary to monitor potential leaching of stabilized contaminants into the dissolved phase.

Similar to LNAPL, if the dissolved phase plume is massive and unstable, pump-and-treat can be used to hydraulically control the plume and treat the contaminants. However, the pump-and-treat system will need components that treat both metals and organic contaminants from the commingled plumes. Granular activated carbon or other absorbing materials can be used to treat the recovered petroleum hydrocarbons in the system, but are not effective for metals. Therefore, another treatment train would be needed, which may include an ion exchange system or a pH adjuster to precipitate metals. The system can become complex, and costs can be high for operation and maintenance. In addition, low recovery rates of the temporary wells and low hydraulic conductivity observed at the site may limit the cost-effectiveness of a pump-and-treat system.

ISB is an *in situ* technology to consider, and it involves injection of amendments into groundwater to stimulate aerobic biodegradation of benzene, naphthalene, and other petroleum hydrocarbons. Commercially available products of ISB amendments include the oxygen-releasing compounds by Regenesis and PermeOx by PeroxyChem. Although ISB will probably not directly address the lead, arsenic, and other dissolved metals in the groundwater, added oxygen-containing compounds can also react with dissolved metals, specifically dissolved iron and manganese, to generate iron and manganese oxides, which can bind and precipitate lead and arsenic.

ISCO as another *in situ* technology involving injection of chemical oxidant amendments into the subsurface to transform contaminants in groundwater into innocuous byproducts. Common ISCO reagents include hydrogen peroxide, sodium persulfate, potassium permanganate, sodium percarbonate, and ozone. These reagents can efficiently oxidize a wide range of compounds including benzene, naphthalene, and other organic compounds. However, ISCO may mobilize metals, especially for redox sensitive metals (i.e., chromium, arsenic, and lead). Therefore, it is not applicable for the areas with metal exceedances and could potentially make metal plumes worse. In addition, LNAPL presence at the site may lower the effectiveness of ISCO by coating the reagent particles and reducing reaction potential with the contaminants.

Provect-OX®, a commercial product made by Provectus Environmental Products, Inc., was found to be able to oxidize naphthalene and pentachlorophenol in the groundwater at another EPA Superfund site without increasing metal concentrations. Provect-OX® contains persulfate (as an oxidant) and ferric iron (as an activation agent) in a single premixed package. It has been found that residual iron and sulfate generated from persulfate decomposition can be used as electron acceptors for facultative reductive processes. Therefore, Provect-OX® may promote secondary enhanced bioremediation to manage residuals in the groundwater, which may be applicable to the site groundwater. A bench scale treatability study for ISCO must be conducted to determine a sufficient dosing of the oxidant to account for natural oxidant demand in the subsurface and also evaluate potential metal mobility caused by the oxidant.

Technologies that require injection target treated areas directly, so enhanced distribution of reagents is very important for improving treatment efficiency. The site's high heterogeneity may be a concern for injected reagents to be evenly distributed to the contaminated subsurface. Therefore, ISS can be an option to overcome the shortcomings at the site. During ISS, a large diameter rig is used to mix and homogenize amendments with soil/groundwater. The mixed materials are then used to form monoliths with certain strength and structural integrity to hold the contaminants in place. The use of monolith structures aide in minimizing leaching to the groundwater. Typical ISS reagents include Portland cement, slag, fly ash, bentonite, organoclay, and powdered activated carbon. ISS can effectively stabilize metals and petroleum hydrocarbons in the groundwater but has been found to not be able to reduce naphthalene leaching potential in some projects. Therefore, it may be used in the source areas to significantly reduce the source contributions to the dissolved plumes. This option can address both soil and groundwater contaminated with LNAPL, metals, and organic compounds at the same time because the rig can mix reagents from unsaturated to saturated zones in one operation. A bench scale treatability study is required to develop an optimal reagent mixture prior to a full scale ISS implementation. In addition, as stated previously, institutional controls are required to prevent any earth moving activities in the ISS treated area.

Based on data gaps, the groundwater evaluation is taken no further, and the remainder of this FS will focus on soil.

3.3 GROUNDWATER USE

Groundwater in the process areas of the site is not currently used as a tap water source. It is noted that the State of Oklahoma does consider the shallow, perched groundwater as a “General Use Groundwater (Class II),” which can be used for beneficial use (ODEQ 2020). As a result, the restoration of groundwater to potential beneficial use is considered the primary objective for the selection of groundwater PRGs.

4. REMEDIAL ACTION OBJECTIVES

This section proposes Remedial Action Objectives (RAOs) and preliminary remediation goals (PRGs) for contaminated soil at the site, as well as discusses Applicable or Relevant and Appropriate Requirements (ARARs). Additionally, the areas and volumes of contaminated soil exceeding the PRGs and used to support and evaluate technologies in this FS are provided.

4.1 REMEDIAL ACTION OBJECTIVES

RAOs define what the remedial actions should accomplish to protect potential receptors. Consistent with EPA guidance and the National Contingency Plan (NCP) (40 Code of Federal Regulations [CFR] § 300.430(e)(2)(i), these objectives consider the following:

- COPCs
- Exposures based on risk assessments, including Applicable or Relevant and Appropriate Requirements (ARARs)
- Receptors
- PRGs

Human Health

4.1.1 Soil

The HHRA identified that there are potential human health concerns associated with exposure to soil under future anticipated land uses.

Benzo(a)pyrene

Potential exposures to benzo(a)pyrene in soil at the site exceed the excess cancer risk of 1x10-4 for the Future On-Site Child Resident exposed to soil within he Lorraine Process Area through direct contact, ingestion, and inhalation pathways.

Lead

Potential exposures to lead in soil at the site may pose a potential risk for the Future On-Site Child having a greater than 5% chance of exceeding target blood-lead levels of either 5, 8 and/or 10 micrograms per deciliter within the Lorraine Process Area and the Wilcox Process Area.

Potential exposures to lead in soil at the site may pose a potential risk for the Future Commercial/Industrial Worker having a greater than 5% chance of exceeding target blood-lead level of 5 micrograms per deciliter within the Lorraine and Wilcox Process Areas.

4.1.1.1 Waste Materials

Most of the waste at the site is relatively shallow. The waste materials encountered consisted primarily of surficial, crusted tar-like materials, in some cases flowable tar-like material, black stained soil, and oily soil.

Early in the remedial investigation process nine (9) source areas (the lead additive area and 8 tank waste locations) were identified for early action; therefore the source control action is limited in scope to address these specific source areas. The areas that are addressed under the Source Control ROD are presented in Figure 2-4.

All remaining waste materials were sampled and investigated during the remedial investigation and are evaluated under this FS in relation to the RAOs and PRGs developed for soil and associated with the Future Child Resident.

4.1.2 Sediment and East Tank Farm

Although the HHRA, did not identify excess human health risks concerns for exposure to sediment within Sand Creek, the tributaries, or onsite and nearby ponds, the pond and tributary located within the Wilcox Process area is routinely dry and accessible by future residents. The pond and tributary are adjacent to the lead additive area and received run-off containing concentrations of lead that result is potential human health and ecological risk. Additionally, this tributary and pond discharge to Sand Creek. As a result, the sediment in the tributary and pond are considered soil and are evaluated under this FS in relation to the RAOs and PRGs developed for soil and associated with the Future Child Resident.

Likewise, the HHRA did not identify human health concerns related to exposures to lead for the East Tank Farm; however, the western portion of the East Tank Farm has several locations that will be considered part of the soil remediation for lead due to the presence of lead at concentrations consistent with those present within the Lorraine and Wilcox Process Areas. There are four locations and the associated concentrations are ETF-SB-136-0.5 (2,100 mg/kg) and ETF-SB-136-2.0 (2,730 (mg/kg); ETF-SB-142-2.0 (729 mg/kg); ETF-SB-131-0.5 (555 mg/kg) and ETF-SB-131-2.0 (687 mg/kg); and ETF-SB07-116-1.0 (356mg/kg). The soil will be considered and evaluated under this FS in relation to the RAOs and PRGs developed for soil and associated with the Future Child Resident.

4.1.3 Groundwater

As noted in Section 3, data gaps associated with groundwater need to be addressed; therefore, no RAOs or PRGs are provided in the FS.

4.1.4 Ecological

As noted previously in Section 2.8.2, no ecological remediation goals are identified based on the results of the ecological risk assessment. Contaminants identified as posing a potential threat to ecological receptors were further assessed with the following conclusions.

- Contaminants of potential concern, lead and vanadium, are collocated in areas where human health risk will be addressed; therefore, these metals and associated risks to ecological receptors will be addressed.
- Concentrations of PAHs are lower than concentrations expected to pose potential risks (i.e., probable effect level for benthic organisms).

- The presence of volatile organic compounds is sporadic and infrequent and these compounds readily evaporate into the air. There is an absence of direct toxicological studies and uncertainty associated with the soil screening values for these compounds. Based on this, it is not expected that VOCs would result in unacceptable risk.
- Potential risks to aquatic organisms in the ponds (cadmium, lead, benzo(a)pyrene) and streams (manganese) from elevated concentrations of contaminants in the water column are likely to be reduced following removal of contaminated soil in the uplands.
- It is unlikely that there would be adverse impacts to the plant or soil invertebrate communities at the site from sporadic elevated concentrations of metals (zinc, manganese, copper, and chromium) based on the following.
    - Potential risks are based solely on a screen against Ecological Soil Screening Levels or screening benchmarks from Efroymson et al. (Efroymson et al 1997a,b).
    - Low potential for uptake and toxicity from naturally occurring metals, many of which are essential nutrients.
    - Sporadic elevated concentrations not linked to facility activities.
    - Lack of sufficient ecological habitat from long-term and/or continued future industrial, residential, and agricultural usage of many portions of the site.
    - Cleanup of soil areas associated with human health risk will also address concentrations of other metals and contaminants, thus reducing the overall exposure concentration and associated potential risk.

4.2 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Remedial actions must protect public health and the environment. Section 121(d) of CERCLA requires that federal and state ARARs be identified and that response actions achieve compliance with the identified ARARs. This requirement makes CERCLA response actions consistent with pertinent federal and state environmental requirements as well as adequately protecting public health and the environment. Therefore, compliance with the ARARs is included in the development and evaluation of the remedial alternatives.

4.2.1 Definition of Applicable or Relevant and Appropriate Requirements

As defined in the NCP, "applicable requirements" are cleanup standards, standards of control, criteria, or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only the state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable (40 CFR 300.5).

Relevant and appropriate requirements may not specifically apply but may address similar issues or situations that might be encountered at the site. A requirement must be either applicable or both relevant and appropriate to be selected as an ARAR.

4.2.2 Classifications of Applicable or Relevant and Appropriate Requirements

ARARs for remedial alternatives can be generally classified into the following three categories:

- ***Chemical-Specific*** are usually based on health- or risk-based numerical values or methodologies used to determine acceptable amounts or concentrations of chemicals that may be found in, or discharged to the environment, i.e., MCLs or State Water Quality Standards.

- ***Location-Specific*** are restrictions placed on the concentrations of hazardous substances or activities solely because they are in certain environmentally sensitive areas. Some examples of special locations regulated under various federal laws include floodplains, wetlands, historically significant cultural resources, and sensitive ecosystems or habitats.

- ***Action-Specific*** are usually technology- or activity-based requirements or limitations on actions or conditions involving specific substances.

In addition to these three categories, some EPA and State guidelines also need "to be considered" (TBC). The TBC are non-promulgated advisories, non-enforceable guidelines or criteria and standards useful for developing a remedial action criterion or evaluating protection of human health and / or environment. Examples include EPA reference doses and risk specific doses that may be used for determining the level of cleanup.

Table 4-1 presents the ARARs for the site. These ARARs are identified based on the site conditions and in consideration of potential remedial alternatives developed in the FS.

4.3 PRELIMINARY REMEDIATION GOALS

PRGs were determined for each of the chemicals identified as COPCs. PRGs were developed for chemicals with cancer risks greater than 10^{-6} and target organ specific Hazard Index (HI) greater than 1. Detailed information on PRG calculations is included in Appendix C. The site-specific PRGs are chemical limits calculated using toxicity values and site-specific exposure conditions evaluated in the HHRA (EA 2020). The HHRA determined potential health concerns for selected receptors exposures to lead in soil (Lorraine Process Area and Wilcox Process Area) and benzo(a)pyrene in soil (Lorraine Process Area).

The following equations were used to calculate site-specific PRGs:

<u>For carcinogens:</u>

$$Site - Specific\ PRG\ = \frac{EPC}{Risk} \times TR$$

Where,
TR = target carcinogenic risk level (i.e., 10^{-6}, 10^{-5}, 10^{-4})
Risk = chemical-specific cumulative carcinogenic risk shown in HHRA
EPC = chemical-specific exposure point concentration presented in HHRA.

<u>For non-carcinogens:</u>

$$Site - Specific\ PRG\ = \frac{EPC}{HQ} \times THQ$$

Where,
THQ = target hazard quotient (i.e., 1)
HQ = target organ specific and chemical-specific total hazard quotient shown in HHRA
EPC = chemical-specific exposure point concentration presented in HHRA.

The calculated PRGs for the site soil COPCs, lead and benzo(a)pyrene, for each receptor are listed below:

Residential lead PRGs based on a child resident.
- Lead - 200 mg/kg (residential use) at a target blood lead level of 5 ug/dl.
- Lead - 300 mg/kg (residential use) at a target blood lead level of 8 ug/dl.
- Lead - 400 mg/kg (residential use) at a target blood lead level of 10 ug/dl.

Commercial/Industrial lead PRGs based on a commercial/industrial worker.
- Lead - 460 mg/kg (commercial/industrial use) based on a target blood lead level of 5 ug/dl.
- Lead - 846 mg/kg (commercial/industrial use) based on a target blood lead level of 8 ug/dl.
- Lead – 1,103 mg/kg (commercial/industrial use) based on a target blood lead level of 10 ug/dl.

Residential benzo(a)pyrene PRG based on excess cancer risk of 1x10-6 for a child/adult resident.
- Benzo(a)pyrene – 0.12 mg/kg (residential) at an excess cancer risk of 1x10-6

As noted in Section 4.1.4, addressing the risks to human health address the ecological risks based on the future land use, which is assumed to be residential use at the site. The southern portion of the Wilcox Process Area is anticipated to be used for commercial/industrial use; however, consideration as residential remains.

Lead is classified as a probable human carcinogen; however, EPA has not published a slope factor or inhalation unit risk for quantifying carcinogenic risks. Blood lead levels are the indicators of excess lead exposure in humans. To ensure the appropriateness of PRG selection, lead PRGs were determined based upon the blood-lead levels of 5, 8, and 10 micrograms per deciliter of lead in blood. The Integrated Exposure Uptake Biokinetic (IEUBK) model was used to determine the appropriate PRGs for the various blood-lead levels. For the worker, the EPA Adult Lead Model was used to determine the appropriate PRGs for the various blood-lead levels.

As noted in Section 4.5, the difference in the volume of soil addressed under a residential scenario versus a commercial/industrial scenario for the Wilcox Process Area is minimal and estimated at approximately 4,275 cubic yards. Therefore, the lead PRG of 200 mg/kg (residential use) at a target blood lead level of 5 ug/dl is selected as the PRG that will be used to evaluate potential remedial alternatives in this FS. This PRG is protective of the child resident, the commercial/industrial worker, and ecological receptors. Using a residential PRG also addresses contamination and allows for unlimited use and unrestricted exposure to the soil and would not require future operations and maintenance or institutional controls.

4.4 REMEDIAL ACTION OBJECTIVES

The RAOs were developed for contaminated soil to address unacceptable human health risks identified through the risk assessment process taking into account potential future land use and contaminant exposure pathways.

RAO: Prevent human (and ecological) direct, inhalation, and ingestion exposures to soil (including the drainage and pond sediment within the Wilcox Process Area) for the future resident child containing lead concentrations of 200 mg/kg or greater that potentially result in a greater than 5% chance of exceeding a target blood lead level of 5 ug/dl.

RAO: Prevent human direct, inhalation, and ingestion exposures to soil for the future resident child containing benzo(a)pyrene concentrations of 0.12 mg/kg or greater that result in an excess cancer risk greater than 1x10-6.

4.5 OCCURRENCE AND VOLUME OF SOILS ABOVE PRGS

The soils exceeding the lead PRG are identified across the Wilcox and Lorraine Process Areas and the western portion of the East Tank Farm. The soils exceeding the benzo(a)pyrene PRG are located in the Lorraine Process Areas. Figures 2-5 and 2-6 show the areas.

For the purpose of this FS, the exceedance boundaries are estimated based on the assumption that a boundary line is in the midpoint between the sampling point with the exceedance and the nearby sampling point of non-exceedance. The depth of excavation is estimated to be 2ft which is consistent with data results as well as exposure scenarios. Additional sampling at the time of the design can be completed to further refine the extent of the contaminated soil and reduce uncertainty related to the location and size of remediation areas. The estimated volume of impacted soil including sediment is as follows:

- Lorraine Process Area –

This area is considered residential and contains several locations exceeding the benzo(a)pyrene PRG (Figure 2-5). The benzo(a)pyrene contamination depth is from 0 to 2 ft bgs and covers approximately 9,528 sf. There are also three areas with exceedances of the lead PRG (Figure 2-5). The depth of lead contamination is from 0 to 2 ft bgs. The lead exceedance areas cover a total of 46,985 sf.

Soil Volume Estimate: Lorraine Process Area						
Lorraine		Area (ft)	Depth (ft)	ft3	y3	Total y3
	Residential	9528	2	19056	706	
	Residential	9210	2	18420	682	
	Residential	BaP 1	2			
	Residential	BaP 2	2			
	Residential	BaP 3	2			
	Residential	28225	2	56450	2091	
	Residential	9550	2	19100	707	4186

- Wilcox Process Area – 15,390 cys for lead, and 3,260 cys lead . In addition, 1,000 cy of sediment for lead

This area is divided into two areas based on the land use; one is a residential area and the other area is commercial/industrial; however, residential remains a consideration for all of the Wilcox Process Area. Based on this uncertainty, the estimated volumes based on the residential and the resident/commercial/industrial future uses are presented.

The residential area is assumed to be located in the northern Wilcox Process Area and includes the house, storage tanks, and driveway (Figure 2-5). The depth of the lead contamination is from 0-2 ft bgs. Three sediment samples, considered as soil as noted in previous sections, also exceed the soil residential lead PRG. The exceedance area covers approximately 53,394 square feet (sf) with an estimated volume of 3,955 cubic yards (y3).

The industrial area exceeds the lead PRG at multiple sample locations (Figure 2-6). The depth of the lead contamination is primarily from 0 to 2 ft bgs. The exceedance area covers approximately 177,661 square feet (sf) with an estimated volume of 13,160 y3. The total estimated volume of soil under the resident/commercial/industrial future uses is 17,115 y3.

Soil Volume Estimate: Wilcox Process Area (Residential and Commercial/Industrial)						
Wilcox		Area (ft)	Depth (ft)	ft3	y3	Total y3
	Residential	39942	2	79884	2959	
	Residential	13452	2	26904	996	3955
	Commercial/Industrial	7324	2	14648	543	
	Commercial/Industrial	9336	2	18672	692	

	Commercial/Industrial	110,441	2	220882	8181	
	Commercial/Industrial	10456	2	20912	775	
	Commercial/Industrial	30151	2	60302	2233	
	Commercial/Industrial	9953	2	19906	737	13160
		Total Residential/Commercial/Industrial				17115

Assuming all of the Wilcox Process Area is residential and the depth of the lead contamination is from 0-2 ft bgs, the estimated area covers approximately 288,767 square feet (sf) with an estimated volume of 21,290 cubic yards (y3).

Soil Volume Estimate: Wilcox Process Area						
Wilcox		Area (ft)	Depth (ft)	ft3	y3	Total y3
	Residential	39942	2	79884	2959	
	Residential	13452	2	26904	996	
	Residential	7324	2	14648	543	
	Residential	9336	2	18672	692	
	Residential	180421	2	360842	13365	
	Residential	11479	2	22958	850	
	Residential	26813	2	53626	1986	21390

The difference between addressing the Wilcox Process Area as residential versus Residential/Commercial/Industrial is an estimated 4,275 cubic yards. The additional volume of soil needing to be addressed under the residential scenario is minimal; therefore, the lead PRG is identified as Lead - 200 mg/kg (residential use) at a target blood lead level of 5 ug/dl. This is protective of the resident, the commercial/industrial worker, and ecological receptors. Using a residential cleanup level removes contamination to allow for unlimited use and unrestricted exposure to the soil and would not require future operations and maintenance or institutional controls. The residential assumption and estimated volumes are carried through the Comparison of Alternatives.

- East Tank Farm – 8441 cys for lead.

This area is considered residential use and contains three lead exceedance areas. The depth of lead contamination is from 0 to 2 ft bgs, and the three areas cover a total of approximately 113,948 sf (Figure 2-5) with an estimated volume of 8,441 y3.

ETF		Area (ft)	Depth (ft)	ft3	y3	Total y3
	Residential	24917	2	49834	1846	
	Residential	58688	2	117376	4347	
	Residential	30343	2	60686	2248	8441

In summary, a total of ?????????contaminated soil and sediment with concentrations above the PRGs are used to evaluate and compare soil alternatives in this FS (Figures 2-5 and 2-6).

Total Soil Volume Estimate						
		Area (ft)	Depth (ft)	ft3	y3	Total y3
Lorraine Process Area	Residential	??	??	??	??	
Wilcox Process Area	Residential	288767	2	577534	21390	
East Tank Farm	Residential	113948	2	227896	8441	??

5. DEVELOPMENT AND SCREENING OF TECHNOLOGIES

This section describes the process of development and screening of technologies. The development process starts by identifying general response actions (GRAs) and associated technologies for soils. The remedial technologies are then screened under the three criteria: effectiveness, implementability, and cost.

5.1 GENERAL RESPONSE ACTIONS AND REMEDIAL TECHNOLOGIES

GRAs may include institutional actions, containment, treatment, removal, disposal, or a combination of these as described in the EPA 1988 guidance (EPA 1988). As required by the NCP (40 CFR §300.430.e.6), selected remedial alternatives must include no further action (NFA) to be used as the baseline against which the effectiveness of all other alternatives are evaluated. Thus, NFA is included in the alternative evaluation for the site soil.

NFA means nothing is done to the site. NFA does not control, contain, or remediate contaminant sources, and it does not reduce the mobility, volume, or toxicity of the contamination at the site.

In addition, ICs are also included in evaluation of alternatives. ICs may include restrictions on land use, access restrictions, environmental monitoring, security measures, notification, and education advisories to inform the public and adjacent landowners about the site. Common ICs include zoning, enforceable land use restrictions (i.e., deed notice and covenant restriction), and long-term environmental monitoring.

The GRAs suitable for the site soils include following:

- NFA
- ICs
- Containment
- Removal / disposal
- Treatment.

Table 5-1 presents the GRAs and their individual technologies considered in this section.

5.2 REMEDIAL TECHNOLOGY SCREENING

This section presents and screens the remedial technologies presented in Table 5-1.

5.2.1 Preliminary Screening Criteria

Three preliminary screening criteria (i.e., effectiveness, implementability, and cost) were used to screen the remedial technologies. Definitions for these criteria are presented below.

Effectiveness is a measure of a technology's ability to: (1) reduce toxicity, mobility, or volume; (2) minimize residual risks; (3) afford long-term protection; (4) comply with ARARs; (5) minimize short-term impacts; and (6) achieve protectiveness in a limited duration. Technologies that are significantly less effective than other technologies may be eliminated from the alternative development process. Technologies that do not provide adequate protection of human health and the environment are also eliminated from further consideration.

The effectiveness evaluation is focused on the following elements:

- Potential effectiveness of technologies in handling the areas or volumes of the soil to meet the RAOs.

- Potential impacts to human health and the environment during the construction and implementation phase.

- Reliability and proven effectiveness of the technologies with respect to the COCs under site-specific conditions.

Implementability is a measure of both technical and administrative feasibility of implementing a technology process. Initial technology screening eliminates technologies that are clearly ineffective or unusable at the site. Implementability aspects include:

- Technical feasibility that may include constructability or workability under site conditions, being able to operate and maintain to meet the PRGs, and the complexity of the technology.
- Administrative feasibility that may include permitting, and accessibility (easements, rights-of-way required; access to the properties to be addressed; and ability to impose ICs).
- Availability of services and materials which may include availability of special equipment, materials and specially trained and skilled workers required, and offsite treatment and disposal capacity.

Cost (capital and operation and maintenance costs) is a measure of resources that are required in technology implementation. The costs used in this document were obtained from published resources and previous projects. Cost evaluation at the technology screening phase is relative, typically presented as high, low, or medium compared to other technologies within the same technology type. The technologies with high cost but low protection of human health and environment are not considered for further evaluation.

5.2.2 Technology Screening Summary

Table 5-1 presents the rationales for technologies retained or eliminated based on the three preliminary criteria. The soil technologies and process options retained for further evaluation include NFA, ICs, excavation, containment and disposal. Based on the site conditions and as described previously, no treatment technologies have been retained as soil alternatives.

5.2.2.1 NFA (Retained)

NFA has been retained in accordance with the requirements of Subpart F of the NCP as a baseline for comparison with the other technologies.

5.2.2.2 Land Use Controls (Retained)

Land use controls (LUCs) are administrative measures developed to protect human health and safety from the presence of hazards. LUCs are measures that limit access or use of a property to protect people from site hazards or provide warnings of a potential site hazard. LUCs include engineering controls and physical barriers (e.g., fencing), educational programs (e.g., public notification of residual concerns), and administrative and legal controls (e.g., zoning restrictions and easements) that help to minimize the potential for human exposure. They have been retained for alternative development.

LUCs would be effective for reducing the potential exposure to the site soil. LUCs are implementable and costs are low, therefore, LUCs are retained.

5.2.2.3 Excavation (Retained)

Excavation can involve removal of all impacted soil and "hot spots" from a site. Excavation is a well-proven and effective method for removing impacted materials from a site to prevent direct contact and exposure to the contaminants. Therefore, it will address the relevant remedial objectives for the site. Excavation is a mature technology and easily implemented. Cost for excavation is low compared to other technologies. Therefore, this technology is retained for further consideration.

5.2.2.4 In Situ Treatments (Not Retained)

In situ treatment technologies treat contaminants in place. Compared to *ex situ* treatment technologies, *in situ* remedial technologies handle contaminated media in place; therefore, its process of handling hazardous materials potential is low, as well as disposal costs and exposure of the workers to the contaminants.

In Situ Solidification/Stabilization

In situ solidification/stabilization processes involve adding and mixing reagents with soil to trap, treat, or immobilize contaminants. This technology is typically implemented by grouting or using a large-diameter auger or other equipment to mix with soil while adding reagents. Treated soil will become stabilized to prevent contaminants from leaching out to groundwater. Types of solidifying/stabilizing reagents include Portland cement, fly ash, blast furnace slag, bentonite, organoclay, and powdered activated carbon. Note that *ex situ* solidification/stabilization is discussed separately under *Ex Situ* Treatment section.

In situ solidification/stabilization can be effective in stabilizing the contaminated soil and reducing contaminant migration vertically and horizontally. Overall this technology will reduce the site risks and protect human health and environment. A treatability study is required prior to a full scale implementation to develop mixtures of reagents. However, the site contaminated soil is non-hazardous and is a low-level threat (not a principal threat waste) to the environment, *in situ* solidification/stabilization, or any other treatment technologies, therefore would not be cost effective compared to non-treatment technologies. In addition, ICs are required to protect the treated areas from intrusive activities, i.e., excavation, drilling and injections, which may limit future site use and development. Cost of *in situ* solidification/stabilization is high compared to other technologies. Therefore, this technology is not retained because of the high cost and waste still remaining in place at the site.

Phytoremediation

Phytoremediation is a process that uses plants to remove, transfer, stabilize and destroy contaminants in soil. There are six general approaches to phytoremediation: phytoaccumulation, phytodegradation, phytostabilization, phytovolatilization, rhizodegradation, and rhizofiltration (Interstate Technology and Regulatory Cooperation Work Group [ITRC] 1999). A variety of plants have shown limited uptake of metals and benzo(a)pyrene in surface soil. A pilot treatability study is necessary to develop ideal environmental conditions for plant growth and remediation before a full-scale implementation. Although it is relatively easy to implement, the effectiveness of phytoremediation may not be reliable and relies on plant types, seasonal temperature change, soil type, pH, and moisture content. In addition, phytoremediation may require an extended time period compared to several other technologies. Cost of phytoremediation is low to medium depending on needs for long-term maintenance, replanting, and monitoring. Therefore, due to unreliability and uncertainty in effectiveness this technology will be not be retained for further consideration.

5.2.2.5 Ex Situ Treatments (Not Retained)

Ex situ treatment involves the excavation and subsequent treatment of soil. The treated soil is either used as backfill within the site or taken offsite for final disposal depending on the final results of the treatment.

Landfarming

Landfarming is a bioremediation technology in which excavated soils are placed in land treatment units (LTUs) and mixed and tilled periodically to blend nutrients/amendments and water to enhance the biological activity within the LTUs. The LTUs are constructed with an impermeable liner i.e., compacted clay or high density polyethylene (HDPE) geomembrane, to protect the soil underneath the treatment area. Sprinkler systems are required for most of the cases to provide irrigation for the system (FRTR, 1997).

Landfarming typically is applicable for treatment of lighter petroleum compounds and it becomes less effective for the PAHs with more aromatic rings, i.e., benzo(a)pyrene. It is not certain with current data available if landfarming is effective for lead in soil. In addition, landfarming is easy to implement but it may require a long period of time for microorganisms to degrade or stabilize the soil COCs, although the cost is low; therefore,landfarming is eliminated from further evaluation.

Ex Situ Solidification/Stabilization

Ex situ solidification/stabilization involves excavating and mixing contaminated materials with reagents to stabilize contaminants. The *ex situ* process is typically applicable to hazardous wastes to reduce the leaching potential and remove their hazardous/toxic characteristics before offsite disposal.

Ex situ solidification/stabilization is effective for lead in soil and is implementable, but the cost may be high. Based on the site data, the majority of the site soil is non-hazardous, which would not require treatment if disposed offsite. This technology does not provide better benefits for the soil remediation compared to non-treatment technologies; therefore, it is not considered for further evaluation.

Soil Washing

Soil washing is a process using a solution of leaching, surfactant, pH-adjustment or chelating agent to remove contaminants. The wash solution with washed COCs is treated by conventional wastewater treatment methods and treated soil can typically be reused onsite or sent offsite for non-hazardous disposal. This process can also be used to separate fines from coarse materials. The majority of contaminants are sorbed to the fines, and once separated the coarse materials could be reused.

Soil washing is an effective method for separating metals from soil. It is implementable with commercially available equipment. However, the process is complex and produces a large amount of wastewater, which can increase the cost significantly. Therefore, it is not considered for further evaluation.

5.2.2.6 Offsite Disposal (Retained)

Disposal includes placement of waste materials in a permanent repository that is subsequently managed to prevent reintroduction of contaminants into the environment. Waste material and contaminated soil removed from the site must be disposed of at an appropriate waste management facility.

Offsite disposal is an effective process for permanently removing impacted soil. Regulatory requirements regarding waste characteristics for the disposed soil would dictate the type of landfill facility. It is implementable and cost is at an average level compared with other technology. This option adequately addresses the RAOs, therefore this process will be retained for further consideration.

5.2.2.7 Onsite Containment (Retained)

Containment technologies control human and/or ecological exposure to COCs by preventing the migration of COCs and/or preventing direct contact with impacted media. Onsite containment includes consolidation and placement of impacted soil under a protective cover or into a containment repository constructed onsite to prevent exposure and minimize the potential migration of COCs.

An onsite containment will address the relevant remedial objectives. It is implementable but it will require ICs to protect the integrity of the repository.

6. DEVELOPMENT OF REMEDIAL ALTERNATIVES

This section presents the remedial alternatives that were retained for the site soil during the technology screening. The technologies retained were assembled to develop a range of alternatives and provide flexibility in selecting preferred alternatives. The development of the alternatives was based on the EPA's document, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988), which advises to include:

- Alternatives that permanently reduce the toxicity, mobility, or volume of contaminants. The range of alternatives should, if possible, vary in the degree of reliance on long-term management of untreated wastes;

- Permanent solutions to the maximum extent practicable;

- Use of innovative treatment technologies and resource recovery technologies to the maximum extent practicable;

- One or more containment alternatives that involve little or no treatment of hazardous contaminants; and ,

- A "No Action" alternative.

The following remedial alternatives were identified as potential alternatives for the soil:

- Alternative S-1: NFA
- Alternative S-2: Soil excavation and offsite disposal
- Alternative S-3: Soil excavation and onsite containment repository
- Alternative S-4: Soil excavation, and onsite consolidation and capping

Table 6-1 presents a summary of the alternatives and RAOs that each alternative potentially could achieve.

6.1 COMMON COMPONENTS FOR SOIL ALTERNATIVES

There are no common components across all alternatives. However, ICs would be common to all alternatives should the commercial/industrial scenario be selected for the southern portion of the Wilcox Process Area at the time of the Record of Decision.

6.2 ALTERNATIVE S-1: NO FURTHER ACTION

Alternative S-1 assumes no remedial action for soil. It is used as a baseline for comparison to other remedial alternatives as required by the NCP. Under NFA, no remedial actions will be conducted at the site and contaminated soil posing unacceptable risks would be left in place.

6.3 ALTERNATIVE S-2: SOIL EXCAVATION AND OFFSITE DISPOSAL

Alternative S-2 includes excavation of soil exceeding the PRGs and disposal of the material offsite in a Resource Conservation and Recovery Act (RCRA) permitted and licensed landfill. Figures 2-5 and 2-6 show the locations of the soil exceeding the PRGs.

The main components of Alternative S-2 include:

- Pre-excavation delineation of contaminated soil exceeding the PRGs;
- Site preparation including removal of vegetation in the excavation areas, setup of work zones, installation of erosion and sediment controls near the creek and associated tributaries if excavation nearby, and utility clearance;
- Excavation of the contaminated soil;
- Transportation and disposal of the excavated material at an offsite disposal facility; and,
- Backfill and restoration of excavated areas.

A backhoe or excavator is generally used to perform the excavation. It is estimated that approximately ~~40,270 cys~~ of soil will be excavated, sampled for waste characterization, and transported offsite for disposal. After removal of source materials, the excavated area will be documented and sampled to determine area, depth, volume removed, and concentrations of soil at base and sides of excavation. The excavated areas will be backfilled with clean soil from an offsite location and re-vegetated. All excavation areas will be graded for drainage and appropriate erosion controls implemented.
During excavation activities, dust control measures, such as water spray, will be used to mitigate fugitive dust. Air monitoring equipment will be used to establish a safety perimeter based on the presence of potential vapors and/or dust to ensure the health and safety of onsite workers, the surrounding community, and the environment. Onsite workers directly involved in the excavation may be required to use respirators.

It is assumed for purposes of this FS, the excavated soil will be characterized as non-hazardous waste based on historical data. Waste characterized as non-hazardous waste will be transported and disposed of at a RCRA Subtitle D Landfill. If the excavated soil is characterized as hazardous, it will be transported and disposed of at a RCRA Subtitle C Landfill. All trucks will be decontaminated prior to leaving the Site, will be tarped to contain source materials within the bed of the truck, and will only transport material via the preapproved transportation route.

Alternative S-2 will meet the site RAOs by removal of the contamination offsite to prevent direct contact and prevent contaminants migrating to the groundwater and/or surface water. Since the material will be removed from the site, there will not be any post-remedial action maintenance or monitoring, and the site will be available for assumed land uses without restrictions on soil.

6.4 ALTERNATIVE S-3: SOIL EXCAVATION AND ONSITE CONTAINMENT REPOSITORY

Alternative S-3 includes excavating the contaminated soil and consolidating and placing the excavated soil in a containment repository constructed onsite. A potential location of the containment repository can be in the mid-portion of the Wilcox Process Area, as showed in Figure 2-6, which is away from tributaries and drainage basins or creeks. The location of the containment repository will be determined during the remedial design and shall be in accordance with ODEQ solid waste rules and Oklahoma Administrative Code (OAC) 252 Chapter 515. The excavation of the contaminated soil in this alternative is the same as that in Alternative S-2. However, the excavated soil will be placed in an onsite containment repository, rather than being transported offsite for disposal. The containment repository will be constructed to meet the regulatory requirements for RCRA subtitle D landfill and OAC 252:515.

It is estimated that approximately 40,270 cys of soil will be excavated and placed in the repository. Therefore, the repository is assumed to be approximately 360 ft by 150 ft and 20 ft in height.

The main components of Alternative S-3 include:

- Same components from Alternative S-2 for soil excavation, backfill and restoration of the excavated areas.

- Site preparation of the containment repository area including removal of vegetation and setup of the boundaries of the repository based on containment repository design.

- Installation of bottom liner of the containment repository.

- Placement and compaction of the excavated soil in the containment repository.

- Installation of a low permeability cap.

- Implementation of ICs to restrict the land uses in the containment repository area and prohibit any drilling and earth-moving activities at the repository area.

- Implementation of a groundwater program to monitor groundwater around the repository area in accordance with regulatory requirements.

A containment repository in general consists of, from bottom to the top:

- A bottom liner:
    - Compacted clay liner in 12-inch thickness with a hydraulic conductivity less than 1×10^{-7} centimeter per second (cm/s)
    - Geosynthetic clay liner
    - 60-milli-inch (mil) HDPE textured geomembrane

  - Composite drainage net
  - Protective cover.
- Excavated contaminated soil
- A cap:
  - A geosynthetic clay liner with a hydraulic conductivity less than 1×10^{-8} cm/s
  - A textured 60-mil low-density polyethylene geomembrane
  - A drainage layer constructed with composite drainage net
  - A protective soil cover at least 2.5 ft in thickness
  - A vegetation layer at least 6 inches in thickness.

A leachate collection system is assumed not necessary under this alternative. Water in a containment repository may be generated from precipitation entering through the cap, and the initial moisture content of the soil itself. Physical, chemical, and biological processes of the soil compounds can also produce water and other compounds, but the water generated from these processes is small compared to precipitation and infiltration. Due to the impermeable cap of the containment repository, precipitation into the repository would be limited and reduced. Therefore the leachate generated from the repository is likely low. However, if this alternative is selected, design of the repository will need to include a water balance analysis to determine if a leachate collection system is required.

This alternative will address the RAOs by containing the contaminated material in the repository to prevent the direct exposure to the environment and leaching to the groundwater. However, the contaminated soil will remain at the site, thus ICs will be required to restrict the future land use and earth moving activities, which could potentially damage the repository. Groundwater will be monitored to confirm that the bottom liner prevents the contaminants in the repository from leaching to the groundwater. Because waste remains in place above levels that allow for unlimited use and unrestricted exposure, five-year reviews will be required.

6.5 ALTERNATIVE S-4: SOIL EXCAVATION AND ONSITE CONSOLIDATION AND CAPPING

Alternative S-4 includes excavating the contaminated soil and consolidating and capping it at the site. A potential location of the consolidation and capping can be the same as the location of the containment repository under Alternative S-3, as showed in Figure 2-6. The consolidation and capping location shall be selected in accordance with ODEQ solid waste rules and OAC 252 Chapter 515. The location will also be determined by its position away from the creek and residential areas, as well as its centrality. The excavation of the contaminated soil in this alternative is the same as that in Alternative S-2. However, the excavated soil will be placed in a consolidation location and capped, rather than being transported offsite for disposal or placed in a constructed containment repository. The difference between Alternative 3 and Alternative 4 is the bottom liner construction.

The main components of Alternative S-4 include:

- Same components from Alternative S-2 for soil excavation, backfill and restoration of the excavated areas.

- Site preparation of the consolidation and capping area including removal of vegetation, and setup of work zones, staging areas, and the boundaries of the consolidation and capping.

- Placement and compaction of the excavated soil in the consolidation area.

- Installation of a low permeability cap, which would be the same as the cap under Alternative S-3.

- Implementation of ICs to restrict the land use in the capping area and prohibit any drilling and earth-moving activities at the capping area.

- Implementation of a groundwater program to monitor groundwater around the cap in accordance with regulatory requirements.

This alternative will address the RAOs by capping the contaminated soil to prevent the direct exposure to the environment, and minimize infiltration, therefore reducing leaching of the contaminants to the groundwater. However, the contaminated soil will remain at the site, thus ICs will be required to restrict the future land use and earth moving activities. Groundwater will be monitored to confirm that the capped contaminants are prevented from leaching to the groundwater. Because waste remains in place above levels that allow for unlimited use and unrestricted exposure, five-year reviews will be required.

7. EVALUATION OF REMEDIAL ALTERNATIVES

This section evaluates the remedial alternatives developed in the previous section following the EPA's RI/FS guidance (EPA 1988). The alternatives are evaluated based on the nine criteria listed in the NCP. Alternatives are compared, and key tradeoffs among them are identified to determine the most appropriate remedial actions for the site. The approach is designed to provide decision-makers with sufficient information to adequately compare the alternatives and provide the basis for selecting an appropriate site remedy pursuant to CERCLA requirements.

7.1 EVALUATION CRITERIA

The alternatives are evaluated in this section based on the nine criteria required by 40 CFR Section 300.430(e). The nine criteria used to evaluate each alternative are listed below:

Threshold Criteria

- Overall protection of human health and the environment
- Compliance with ARARs

Balancing Criteria

- Long-term effectiveness and permanence
- Reduction in toxicity, mobility, or volume through treatment (TMV)
- Short-term effectiveness
- Implementability
- Cost

Modifying Criteria

- State acceptance
- Community acceptance.

The evaluation criteria are divided into three groups: threshold, balancing, and modifying criteria. The first two criteria are threshold criteria and must be met by the alternative in order to be eligible for selection as a remedial alternative. The NCP (see 40 CFR 300.430 (f)(1)(ii)(C)(1 to 6)), provides for waiving ARARs under six specific circumstances, otherwise ARARs must be met by the alternative in order to be eligible for selection as a remedial alternative. The next five criteria are balancing criteria and are the primary criteria upon which the detailed analysis is based. Unlike the threshold criteria, the five balancing criteria weigh the tradeoffs between alternatives. A low ranking for one balancing criterion can be offset by a higher ranking on another balancing criteria. The last two criteria are modifying criteria which are deferred until the public comment process has ended and comments from the state and community are received. The nine criteria are described in the following subsections.

7.1.1 Threshold Criteria

To be eligible for selection, an alternative must meet the two threshold criterion or, in the case of ARARs, must justify why a waiver is appropriate.

- **Overall Protection of Human Health and the Environment.** A remedy is protective if it adequately eliminates, reduces, or controls all current and potential risks posed by the site through exposure pathways. Evaluation of protectiveness focuses on the reduction or elimination of site risks by the proposed remedial alternative.

- **Compliance with ARARs.** This criterion is used to evaluate whether each alternative will meet all of the federal and state ARARs or whether there is justification for waiving one or more ARARs. Table 4-1 identifies and presents ARARs for the site.

7.1.2 Balancing Criteria

There are five balancing criteria, described below.

- **Long-Term Effectiveness and Permanence.** This criterion is used to assess the residual risks at the site after RAOs have been met. The primary focus of this criterion is the extent and effectiveness of controls used to manage the risk posed by treatment residuals or untreated materials remaining at the site. The following factors will be considered under this criterion:

  - Adequacy and reliability of remedial controls to mitigate the remaining risks after the remedial activities

  - Magnitude of the residual risks after remedial activities.

- **Reduction of TMV through Treatment.** This evaluation criterion addresses the CERCLA statutory preference for treatment options that permanently and significantly reduce the TMV of the contaminants. The following factors will be considered under this criterion:

  - The amount of hazardous materials that will be destroyed or treated
  - The degree of reduction in TMV measured as a percentage of reduction
  - The degree to which the treatment will be irreversible
  - The type and quantity of treatment residuals that will remain following treatment.

- **Short-Term Effectiveness.** This evaluation criterion addresses the effects of the alternative during the construction and implementation phase until the RAOs are met. Under this criterion, alternatives are evaluated for their effects on human health and the environment during implementation of the remedial action. The following factors will be considered:

- Exposure of the community during implementation
- Exposure of workers during construction
- Environmental impacts resulted from implementation and construction
- Time to achieve RAOs
- Sustainability.

- **Implementability.** This criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials that may be required during its implementation. The following factors were considered:

  - Ability and difficulties to construct the technology
  - Ability to monitor effectiveness of the remedy
  - Availability of equipment and specialists
  - Availability of offsite treatment and disposal capacity and services
  - Ability to obtain approvals from regulatory agencies.

- **Cost.** Cost encompasses capital costs and operations and maintenance costs incurred over the life of the project. As stated in the EPA guidance (EPA 2000), cost estimates in the FS are expected to provide an accuracy of minus 30 percent to plus 50 percent (-30 percent to +50 percent). The estimated costs are designed to be used only for evaluating and comparing alternative technologies and not for setting budgets. For cost estimation and comparison purposes, operations and maintenance is assumed to be 30 years; however, operations and maintenance will be required in perpetuity to ensure protectiveness of the remedy.

  The Remedial Action Cost Engineering and Requirements® (RACER) software, Version 11.4, was used to develop order-of-magnitude costs for this FS. RACER® is a parametric and integrated cost estimating program that was developed specifically for estimating costs associated with environmental investigation and remediation projects. It can be used at early order-of-magnitude stages of cost estimating. RACER® has been used by Department of Defense, Department of Energy, contractors, engineering consultants, state regulatory agencies and private sectors.

7.1.3 Modifying Criteria - State and Community Acceptance

State and community acceptance are the two modifying criteria. These two criteria evaluate the issues and concerns of the state and community regarding each alternative. These criteria cannot be evaluated until the state and community have reviewed and commented on the alternatives presented in the FS Report.

7.2 ALTERNATIVE EVALUATION

Evaluation of alternatives consists of the following two components:

- Evaluation of each alternative against seven of the nine evaluation criteria

- Comparative evaluation of alternatives relative to one another to identify key tradeoffs.

Table 7-1 presents the detailed evaluation of soil alternatives individually and following subsection presents comparative evaluation of the alternatives. The detailed evaluation confirms if alternatives achieve the threshold criteria, presents significant aspects and differentiators of the alternatives, and identifies uncertainties associated with the evaluation.

7.3 COMPARATIVE ANALYSIS

This section presents the comparison among the alternatives based on the detailed evaluation of each alternative. The comparison potentially identifies the most favorable alternative on each evaluation criterion. Table 7-2 provides a summary of comparative analysis for the soil alternatives.

7.3.1 Overall Protection of Human Health and Environment

All alternatives, except S-1 NFA, provide overall protection of human health and environment by either removing the soil and disposing offsite or containing the excavated soil onsite, in a construction repository or within a consolidated and capped area. Removing or containing contaminated soil eliminates or reduces the potential for exposures to site contaminants. Alternatives S-3 and S-4 include ICs to restrict land use and protect the containment repository and cap, respectively. Additionally, S-3 and S-4 will require operations and maintenance as well as five-year review to ensure protection.

Alternative S-2 ranks the most satisfactory among the three alternatives regarding protection of human health and environment because the contaminated soil will be removed permanently and disposed offsite in an approved landfill Under Alternatives S-3 and S-4, additional protection measures (i.e., ICs and five year reviews) will be necessary to maintain protection at the site.

7.3.2 Compliance with ARARs

Table 4-1 presents a compilation of the federal, state, and local ARARs identified for the site. Compliance with ARARs is not applicable to S-1, NFS. All other alternatives are expected to comply with ARARs.

7.3.3 Long-Term Effectiveness and Permanence

Alternative S-1 will not provide long-term effectiveness and permanence. Alternative S-2 will provide the best long-term effectiveness and permanence because all contaminated soil is removed and disposed offsite. Alternatives S-3 and S-4 will only provide long-term effectiveness and permanence if certain conditions are met. Since the contaminated soil will remain onsite, Alternatives S-3 and S-4 will require long-term monitoring and maintenance to protect the contaminated materials, eliminate direct exposure to all receptors, and prevent leaching into the groundwater. ICs and five-year reviews will be required to ensure protectiveness.

7.3.4 Reduction of TMV through Treatment

Alternative S-2 reduces toxicity, mobility, and volume of the contaminants with respect to onsite conditions because the contamination will be physically removed from the site, albeit not through treatment. Alternatives S-3 & S-4 reduce mobility of the contaminants with respect to onsite conditions because the contamination will be physically removed and placed in a containment/capped area. The toxicity and volume remain unchanged.

7.3.5 Short-Term Effectiveness

All alternatives, except Alternative S-1, pose short-term impacts during implementation of the alternatives on workers, communities, and the environment; however, the impacts are low. Proper personal protective equipment and best practice management will be used to alleviate the impacts. Alternative S-3 will require the longest time to implement due to the construction of the containment repository. The transportation of waste offsite in Alternative S-2 will present the greatest short-term risk to the community due to the use of local roads and highways to transport materials to the landfill.

7.3.6 Implementability

All alternatives except S-1 involve mature technologies and typical construction methods and equipment. Thus, they are readily implementable. However, Alternatives S-3 and S-4 involve more processes and technologies than Alternative S-2. Constructing a containment repository or a cap under Alternatives S-3 and S-4, respectively, will require more materials compared to Alternative S-2, and will involve a quality control and quality assurance program to ensure the liners or cap are constructed in accordance with the design. Therefore, Alternative S-2 ranks the most satisfactory regarding implementability, followed by Alternative S-4, then Alternative S-3.

7.3.7 Cost

Table 7-1 presents the cost of the alternatives for soil. Appendix D provides the detailed cost estimates. Overall, Alternative S-3 is highest in 30-year net present value among the alternatives.

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Tables

Figures

Appendix A

Responses to Comments on FS Report, Revision 00

Appendix B

Technical Memorandum on Data Gap Investigation

Appendix C

Development of Human Health Risk Based Preliminary Remediation Goals Technical Memorandum

Development of Ecological Preliminary Remediation Goals Technical Memorandum

Appendix D

Detailed Cost Estimates